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Global Value Chains and the Productivity of Canadian Manufacturing Firms

by John Baldwin and Beiling Yan

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^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

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Abstract

The paper examines whether the integration of Canadian manufacturing firms into a global value chain (GVC) improves their productivity. To control for the self-selection effect (more productive firms self-select to join a GVC), propensity-score matching and difference-in-difference methods are used. Becoming part of a GVC can enhance firms' productivity, both immediately and over time. The magnitude and timing of the effects vary by industrial sector, internationalization process, and import-source/export-destination country in a way that suggests the most substantial advantages of GVC participation are derived from technological improvements.

Key words: global value chain, export, offshoring, productivity

JEL No.: F14, F15, L20

Executive Summary

Fragmentation of production in global value chains (GVCs) leads to a finer division of labour and specialization across nations. Increasingly, Canadian manufacturers are being vertically integrated into GVCs—importing intermediates to produce goods that are later exported. This paper analyzes the effects of participation in a GVC on the productivity performance of Canadian manufacturing firms. GVC status is defined as engaging in both importing and exporting.

More productive firms may self-select to join GVCs. The 28% of Canadian manufacturing firms that participated in GVCs during the 2002-to-2006 period tended to be more productive and larger, and to pay higher wages.

To control for the problem that this self-selection gives to any assessment of the impact of becoming a GVC, propensity-score matching and difference-in-difference methods were used to analyze the impact that participating in a GVC had on productivity. The results show that:

- GVC starters became more productive, and this better performance cumulated over time. Alternatively, GVC stoppers suffered a loss in productivity that was more immediate in nature.

- While GVCs were more prevalent in high technology, research and development, and capital goods industries, the benefits of GVC participation extended across many industries.

- The magnitude and timing of the effects of GVC status vary by the method used to become a GVC. The advantages of a vertical international production relationship were generally established first at the import level, and then, broadened to the export level. Some 70% of firms responded to changes in incentives to adopt or abandon GVC status mainly through entering export markets subsequent to their having become an importer. Those who adjusted through exporting benefited the most in terms of productivity growth in the long run. Firms that adjusted through extending an export orientation by also importing saw a more immediate gain or loss in productivity. The cost-saving effect of offshoring was more immediate than the learning effects of exporting.

- While Canada's trade with low-wage countries has been increasing, high-wage countries remain the major source of imported intermediates and the destination for exports. Productivity growth was higher for GVC firms that imported intermediates from and exported products to these high-wage countries. This is consistent with the learning-by-exporting hypothesis and the hypothesis that imports provide a channel of technology diffusion: firms learn more by dealing with buyers and sellers from countries with technological and managerial sophistication. Along with the finding that productivity gains for new GVCs are greatest in the technology sector, this bolsters the inference that a major source of benefit of a GVC comes from technology transfer.

- Firms that ceased being GVCs by terminating imports from low-wage countries suffered the greatest loss in productivity. This suggests a separate benefit of GVC status can be found in cost-savings but that this is primarily restricted to trade with those countries where potential cost savings are highest.

1 Introduction

Production chains transform raw materials into intermediate products, and then, into final goods. The activities involved in this process range from design, through manufacture of parts and accessories, assembly of final products, to marketing and distribution. Each stage must be co-ordinated with the others, either through arm's-length transactions or a vertically integrated firm.

In a global value chain (GVC), production is subdivided into fine slices (Globerman 2011)[1] of specialization along the chain, that leads to trade across international boundaries in order to take advantage of efficiencies in different jurisdictions. In a GVC, "each activity that adds value to the production process can be carried out wherever the necessary skills and materials are available at competitive cost" (Globerman 2011).

The extent of foreign outsourcing of intermediate inputs illustrates the importance of GVC status.[2] According to the Organisation for Economic Co-operation and Development (OECD 2007), in 2003, 54% of the world's manufactured imports were intermediate goods. A Conference Board of Canada study (2008) reported that between 1987 and 2000, the foreign content of Canadian exports on average rose from 28% to 36%. The scope and speed of integration of worldwide production into GVCs has generated speculation about their effects on productivity. This study examines the productivity performance of Canadian manufacturing firms that became part of a GVC in the post-2000 period.

GVC research falls into two main categories. One focuses on the theoretical reason for GVCs (Findlay 1978; Dixit and Grossman 1982; Markusen and Venables 2007; Grossman and Rossi-Hansburg 2008; Baldwin and Venable 2010; Baldwin and Robert-Nicoud 2010; Costinot et al. 2013), governance types and determinants (Gereffi et al. 2005; Antràs and Chor 2012), and impacts on trade patterns and factor prices (Yi 2003; Kohler 2004). The other category focuses on value-chain case studies of individual companies and selected industries, such as textile/apparel and agricultural products (among 650 publications since 1986 listed at the Global Value Chain Initiative website at Duke University, more than 70% are in this category). More recently, an increasing number of studies have documented the magnitude and growth of GVC trade (Hummels et al. 2001; Kimura et al. 2007; Sydor 2011).

Integration of a firm into a GVC is commonly thought to bring economic benefits. Access to larger foreign markets may allow firms to exploit scale economies, learn about new technologies and products, and become more innovative. It also facilitates access to cheaper intermediate products, a wider variety of products, or a higher quality of foreign inputs, all of which may improve efficiency and reduce costs. In addition, competitive pressure in international markets may force plants to improve efficiency. However, few studies have investigated associations between becoming part of a GVC and firm performance.

This paper offers empirical evidence about the impact of GVC participation on firm performance from 2002 through 2006. GVC participation is defined as participation by a Canadian firm in both importing and exporting—a value chain that crosses international boundaries. This includes situations where trade occurs both within a firm and between independent firms. The analysis is based on several micro-datasets that contain information on the characteristics, performance, and imports and exports of manufacturing firms. The econometric approach makes it possible to examine the effect of GVC participation on productivity performance while taking into account possible self-selection bias, and to track firm performance over time after entering or exiting a GVC.

1. See Hummels et al. (2001) for a model explaining international production fragmentation.
2. Globerman (2011) notes that international trade is increasingly concentrated in intermediate, not final, products, but correctly observes that this may not indicate increasing division of the production chain, but rather, a substitution of imported for domestically produced intermediates.

The analysis distinguishes among different means of adopting GVC status—by starting to export, import, or both. An extensive literature has examined exporting and firm performance.[3] Baldwin and Gu (2003) and Baldwin and Yan (2012) outlined the benefits that Canadian manufacturing firms gained when they began to export in the 1990s and post-2000 period. However, transitions into a GVC that involve both exporting and importing have not been investigated. Most empirical work on offshoring has focused on labour market consequences; few studies have investigated the impact on firm productivity.[4] Nor has the literature adequately considered that many firms are both importers and exporters, and that they trade with countries possessing different levels of technological sophistication and labour costs. This paper disentangles the effects of importing versus exporting when a firm begins to participate in a GVC.

This study also assesses whether the benefits of importing and exporting vary by source and destination country. Baldwin and Gu (2004) demonstrated that productivity gains associated with exporting are connected with technological innovation. The issue addressed here is whether the gains from exporting come from participation in a GVC with more advanced countries or with all countries. If the former is true, this supports the argument that the benefit of exporting as part of a GVC comes from learning about technologies, since these opportunities are greatest in advanced countries. Importing intermediates can enhance productivity in a number of ways. If the gains of importing come from trading with lower-wage countries, the advantage of GVC status is more likely to be associated with lower costs of intermediate inputs. But if the benefit of importing comes from trading with more advanced countries, this suggests that it derives from accessing technologies embodied in foreign intermediate goods, consistent with the hypothesis that imports of intermediate goods are a major channel of technology diffusion (Kelly 2004).

Section 2 of this report describes the data used in the analysis and the characteristics of GVC firms. Section 3 explains the analytical method; specifically, propensity-score matching and difference-in-difference regression, which are used to control for the sample selection problem. Section 4 presents results for the Canadian manufacturing sector, by industry group, by the path used to becoming a GVC, and by source and destination countries for imports and exports, respectively. Section 5 concludes.

2 Data and preliminary analysis

As well as "global value chain," (GVC) terms used to describe international specialization of the stages of production include production-sharing, disintegration and fragmentation of production processes, and vertical specialization. Hummels et al. (2001) use "vertical specialization" to refer to the situation where firms use imported intermediate parts to produce goods, which are then exported. These are the firms examined here—manufacturers that both import intermediate inputs and export intermediate or finished products in a sequentially integrated production process across countries. While firms that only export or only import can also be defined as being involved in a GVC, the use of both criteria in this paper highlights the sequential and back-and-forth aspect of global linkage. It increases the likelihood that actual specialization of function exists in the production process, rather than just a wholesaling function supplementary to the production of goods manufactured in the Canadian facility.

3. See Wagner (2007), Lì pez (2005) and Greenaway and Kneller (2007) for a survey of the learning-by-exporting literature. For other recent surveys, see Lì pez (2005) and Greenaway and Kneller (2007).
4. See Olsen (2006) for a survey of the offshoring literature. Work based on industry-level data find some evidence of productivity gains resulting from material offshoring, (Egger and Egger 2006; Amiti and Wei 2009; Daveri and Jona-Lasinio 2008).

2.1 Data

To identify firms involved in GVCs, information is required on firms' imports and exports. These data are obtained by linking Statistics Canada's Annual Survey of Manufactures (ASM) with the Importer Register. The ASM contains information on firm characteristics such as employment, gross and value-added output, total material cost, export status, total export values, ownership, age, and a 6-digit industry code from the North American Industry Classification System (NAICS). The Importer Register contains information on import value by HS10 commodity and source country. The two micro-databases are linked by matching identifiers at the enterprise level (hereafter, firm) for each year.[5] Importers in Canadian manufacturing industries are typically large enterprises: for the 2002-to-2006 period, 52% of firms in the ASM were linked to the Importer Register, accounting for an average of 76% of total manufacturing shipments (Table 1). It is assumed that unlinked ASM firms are not importers.[6]

Information on export destinations is obtained by linking the ASM with the Exporter Register. Some 27% of firms in the ASM were linked to the Export Register, accounting for 96% of total export values in the ASM (Table 1).

5. The technique is explained in Baldwin, Gu, Sydor and Yan (2013).
6. This matching technique produces links of imports to manufacturing firms that directly import intermediate inputs. Some intermediate inputs are imported by intermediaries, which then supply domestic manufacturers. For the importance of this phenomenon, see Baldwin, Gu, Sydor and Yan (2013). Because they cannot be identified, these imports are omitted from this analysis. They probably should be ignored because the fact that intermediaries do the importing suggests that these imports are not really part of a vertically integrated supply chain, or if they are, it has different characteristics.

Table 1
Linkage of Annual Survey of Manufactures (ASM) to Importer and Exporter Registers, Canada, 2002 to 2006

Year	Importer Register		Exporter Registrer			
	ASM firms linked to Importer Register	ASM shipments linked to Importer Register	ASM firms linked to Exporter Register	ASM shipments linked to Exporter Register	ASM exporters linked to Exporter Register	ASM export shipments linked to Exporter Register
	percent					
2002	41	74	22	69	44	97
2003	43	76	21	68	42	96
2004	58	77	32	71	63	96
2005	59	76	32	75	61	95
2006	59	76	29	72	61	95

Sources: Statistics Canada, Annual Survey of Manufactures, Importer Register and Exporter Register.

Imported products comprise intermediate, investment and consumption goods. To identify intermediate goods, several classification sources are used, the main one being the United Nations' Broad Economic Categories (BEC), which distinguishes among intermediate goods, consumption goods, and capital goods. In addition to BEC, the Canadian Input-Output tables and a classification by Feenstra (2009) are used to further group intermediate goods into energy products, non-energy raw material, primary intermediates, processed intermediates, and parts and accessories of capital goods. The BEC categories of "motor spirits," "passenger motor cars," and "goods not elsewhere specified" are excluded, because these categories are used extensively for both final consumption and intermediate uses.

2.2 Preliminary analysis

Based on the criterion that to be defined as participating in a GVC, a firm must both import and export, the majority of Canadian manufacturers were non-GVC firms (Table 2). Non-GVC firms include those that only import intermediates, those that only export, and those that neither import nor export. The percentage of firms in GVCs rose from 22% in 2002 (or 23% in 2003) to about 35% after 2004. This increase reflects a change in the sampling design, which meant that many small, non-GVC firms were not surveyed after 2003. This should not have an impact on the results reported here, because the paper uses a propensity-score method to match and compare firms with similar characteristics (e.g., firm size).

Table 2
Number and percentage distribution of Canadian manufacturing firms, by global-value-chain (GVC) status, 2002 to 2006

GVC status	2002	2003	2004	2005	2006
			number		
All firms in Annual Survey of Manufactures	50,531	50,336	29,526	28,952	30,355
GVC firms	11,213	11,471	10,214	10,322	10,311
Non-GVC firms	39,318	38,865	19,312	18,630	20,044
Only import material	7,124	7,506	5,541	5,504	6,067
Only export	13,693	13,431	5,063	5,050	4,350
Neither import nor export	18,501	17,928	8,708	8,076	9,627
			percent		
All firms in Annual Survey of Manufactures	100	100	100	100	100
GVC firms	22	23	35	36	34
Non-GVC firms	78	77	65	64	66
Only import material	14	15	19	19	20
Only export	27	27	17	17	14
Neither import nor export	37	36	29	28	32

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

In addition to their trading behaviour, GVC firms differ from non-GVC firms in other ways. Mean differences in a number of attributes, obtained by running standard ordinary least squares (OLS) regressions on pooled cross-sectional data over the 2002-to-2006 period, are reported in Table 3. All regressions include year and NAICS 3-digit industry effects, as well as size effects (total employment), except for the employment regression. GVC firms were, on average, more

productive (10%) and larger (116%).[7] They had higher sales per worker (14%) and paid higher wages (6%). They were also more likely to be foreign-controlled.

Table 3
Characteristics differentials between global-value-chain (GVC) and non-GVC manufacturing firms, Canada, 2002 to 2006

Characteristics	GVC firms versus			
	All non-GVC firms	Non-GVC firms (only import intermediates)	Non-GVC firms (only export)	Non-GVC firms (neither import nor export)
	coefficient			
Log of labour productivity	0.100 **	0.050 **	0.140 **	0.170 **
Log of sales per worker	0.140 **	0.050 **	0.260 **	0.250 **
Log of average wages	0.060 **	0.020 **	0.130 **	0.110 **
Log of employment	1.160 **	0.640 **	1.180 **	1.520 **
Foreign-controlled	0.007 **	0.010 **	-0.025 **	-0.001

** significantly different from reference category (p<0.01)

Notes: All nominal variables are deflated by industry-level deflators. All regressions include year and industry (North American Industry Classification System 3-digit level) effects, as well as size effects except for the employment regression.

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

3 Econometric method

The positive correlation between GVC status and performance likely involves a reciprocal relationship. Firms with superior performance are more likely to participate in a GVC, and being in a GVC may improve performance. To examine whether becoming a part of a GVC leads to productivity gains, propensity score matching and difference-in-difference methods are used to control for potential self-selection associated with this reciprocal process.

3.1 Entering or exiting a global value chain

Joining a GVC (offshoring and exporting) incurs fixed costs (Melitz 2003; Helpman et al. 2004) that are required to communicate product specifications, monitor and coordinate workers abroad, and develop a logistics network. In heterogeneous firm models of international trade, the existence of fixed sunk costs is used to argue that firms will offshore and export only if the present value of the expected profits from being in a GVC exceeds the fixed costs of entry. Therefore, the more productive firms (typically, larger ones) are more likely to offshore and export.

At the beginning of a period ($t-1$), a producer is either a GVC or a non-GVC firm. At the end of a period (t), it has either maintained or changed its GVC status. GVC firms may stop exporting or importing or both; non-GVC firms may start exporting or importing or both.

The probability of entering or exiting GVC status ($E_{f,t}$) at time t is modeled as a function of a set of firm-specific attributes ($Z_{f,t-1}$) at time $t-1$, time (α_t) and industry (α_i) fixed effects:

7. Labor productivity is defined as real value-added output per employee, where real value-added is calculated using plant-level nominal value-added output deflated by corresponding industry deflators.

$$\text{Prob}(E_{f,t} = 1) = \Phi(\alpha_t + \alpha_t + \gamma Z_{f,t-1}) \quad (1)$$

Where $Z_{f,t-1}$ includes relative productivity (relative to mean productivity in the same NAICS 3-digit industry), relative employment (relative to mean employment in the same NAICS 3-digit industry), age, and nationality of ownership (domestic versus foreign-controlled) at the start of a period.

Consistent with self-selection, firms that joined GVCs were significantly more productive than those that did not, and firms that exited from GVCs were significantly less productive than those that continued to participate in a GVC (Table 4).

Table 4
Association of selected characteristics with global-value-chain (GVC) participation (probit coefficients, marginal effects), manufacturing firms, Canada, 2002 to 2006

Characteristics	Probability of entering a GVC	Probability of exiting a GVC
	coefficient	
Relative labour productivity	0.004 *	-0.054 *
Relative employment	0.004 *	-0.022 *
Age	0.003 *	-0.005 *
Foreign control	-0.002	-0.071 *

* significantly different from reference category (p<0.05)

Notes: Number of observations, log pseudo likelihood and pseudo r-squared are as follows: for the probability of entering a GVC, 79,658, -28,937 and 0.07, respectively; for the probability of exiting a GVC, 37,126, -20,114 and 0.09, respectively. The regression specification includes time-specific and industry-specific (North American Industry Classification System 4-digit level) fixed effects. Standard errors are corrected for clustering at the firm level.

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

3.2 Propensity-score matching

In an ideal experimental setting, outcomes for firms that change GVC status would be compared with outcomes that they would have experienced had they not changed GVC status. The latter is unobservable.

To create this unobservable counterfactual (the control group), propensity-score matching (Rosenbaum and Rubin 1983) is used. After the conditional probability of changing GVC status is estimated from equation (1), a propensity score is calculated for each firm. Firms that changed GVC status between years $t-1$ and t are matched with firms that had the closest propensity score sharing a common support region and that did not change GVC status. Matching is conducted separately for each period and NAICS 3-digit industry. Balancing tests are conducted to ensure the quality of matching. If necessary, higher-order and interaction terms are added to the probit model to ensure no significant differences in the covariates ($Z_{f,t-1}$) between treated and control samples after matching.

3.3 Difference-in-difference regression

With the two samples created by the counterfactual, treated and control firms are followed over time.

Firm f's performance measures can be written as:

$$\ln Y_{f,s} = \alpha_s^1 + \alpha_{i,s}^2 + \alpha_s^3 E_{f,s-1} + Z_{f,s-0}\alpha_s^4 + \alpha_f^5 + \varepsilon_{f,s} \quad (2)$$

where s is the rescaled time such that a firm changes status at $s=1$. $Y_{f,s}$ is firm f's labour productivity level at time s. $E_{f,s-1}$ is a dummy variable capturing a change in status for firm f at $s=1$. It is set equal to one if the firm changed status (became a GVC firm or ceased to be a GVC firm), and zero if the firm retained its status (remained a non-GVC or GVC firm). $Z_{f,s-0}$ is a set of prior firm-specific attributes at $s=0$, that are defined in equation (1). The parameters $\alpha_s^1, \alpha_{i,s}^2, \alpha_f^5$ capture respectively year-specific, industry-specific, and time-invariant unobserved firm-specific effects.

Propensity-score matching controls for selection bias by restricting the comparison to differences between treated and control firms with similar observable characteristics. This method is still susceptible to non-random selection bias due to unobservable characteristics that are associated with the treated group. Differencing equation (2) reduces the potential selection bias that arises from unobserved time-invariant firm-specific effects. Equation (2), in accumulated growth form, can be written as follows:

$$\ln Y_{f,S} - \ln Y_{f,s-1} = \beta^1 + \beta_i^2 + \beta^3 E_{f,s-1} + Z_{f,s-0}\beta^4 + \mu_f \quad (3)$$

Equation (3) controls for period-specific (β^1) and industry-specific (β_i^2) effects. The coefficient of interest is (β^3), the estimated accumulated productivity growth gap between the treated firms that changed GVC status and the matched control firms with similar attributes that did not change GVC status.

To avoid conflating the effects of multiple GVC entries and exits, productivity performance is compared among firms whose GVC status at time S remains the same as at time $s=1$. For example, for the 2003 cohort $(s=1)$, firms that were not part of a GVC in either 2002 or 2003 are defined as non-GVC firms; those that were not GVC firms in 2002, but became GVC firms in 2003, are defined as GVC starters. To compare the 2003 cohort's performance in 2004 $(s=2)$, firms that changed GVC status again between 2003 and 2004 are excluded. A similar procedure is applied to other cohorts, time periods, and group comparisons between those who continue and those who cease to participate in GVCs.

4 Global value chain status and productivity gains

4.1 Results at the manufacturing level

Overall, being in a GVC is associated with higher productivity growth (Table 5). During their first year in a GVC, firms experienced 5% more productivity growth than did non-GVC firms. The gap accumulated to 9% over four years. Alternatively, in the first year after they ceased to be in a GVC, firms experienced 1% lower productivity growth, compared with continuing GVC firms. The relative loss over four years amounted to 8% (Table 5).

Table 5

Association between change in global-value-chain (GVC) status and accumulated productivity growth, manufacturing firms, Canada, 2002 to 2006

	Accumulated productivity growth by number of years after GVC status change							
	GVC starters versus non-GVC firms				GVC stoppers versus GVC continuers			
	1 year	2 years	3 years	4 years	1 year	2 years	3 years	4 years
Coefficient	0.05 ***	0.05 ***	0.06 ***	0.09 ***	-0.01	-0.05 ***	-0.05 ***	-0.08 ***
Standard error	-0.01	-0.01	-0.02	-0.03	-0.01	-0.01	-0.02	-0.03
Number of observations	17,920	7,774	4,465	2,020	16,842	6,877	4,013	1,781
R-squared	0.15	0.02	0.16	0.21	0.15	0.20	0.21	0.22

*** significantly different from reference category (p<0.001)

Sources: Statistics Canada, Annual Survey of Manufacturers and Importer Register.

4.2 Results by industry groups

To examine how the benefits of GVC participation differ across industries, three industry classifications are used. The first divides industries into four groups according to technological intensity: high, medium-high, medium-low, and low (Hatzichronoglou 1997).[8] The second classifies industries into five industrial sectors: natural-resource-based, labour-intensive, scale-based, product-differentiated, and science-based (OECD 1987).[9] The third classifies industries into non-durable and durable sectors.

The average participation rate in GVCs over the 2002-to-2006 period differed by industrial sector (Table 6). Around half of firms in high-technology and medium-high-technology industries were part of a GVC, compared with 28% for Canadian manufacturing firms overall. The high- and medium-technology industries roughly correspond to the product-differentiated and science-based sectors defined by the second classification system. And according to the third classification system, around 67% of firms in the durable sector were integrated in a GVC, compared with 13% in non-durable industries. Thus, GVC participation was more common in industries that are technologically advanced, in terms of complexity of equipment, research and development (R&D) expenditures, or nature of product.

8. High technology includes industries such as aerospace, computers/office machinery, electronics/communications and pharmaceuticals. Medium-high technology includes scientific instruments, motor vehicles, electrical machinery, chemicals, other transport equipment and non-electrical machinery. Medium-low technology includes rubber and plastic products, shipbuilding, other manufacturing, non-ferrous metals, non-metallic mineral products, fabricated metal products, petroleum refining, and ferrous metals. Low technology includes paper printing, textile and clothing, food-beverages-tobacco, and wood-furniture products. Hatzichronoglou (1997) provides a more detailed description and a listing of industries classified to each group.
9. The classification is from the OECD (1987) and adapted to the Canadian industry classification system by Baldwin and Rafiquzzaman (1994).

Table 6
Annual average participation in global-value-chains, by industrial classification, manufacturing firms, Canada, 2002 to 2006

Industrial classification	Annual average participation (2002 to 2006)
	percent
All firms	28
Technology level	
High	50
Medium-high	45
Medium-low	27
Low	19
OECD industry sector characteristics	
Natural-resource-based	23
Labour-intensive	24
Scale-based	26
Product-differentiated	38
Science-based	49
Non-durable/durable goods	
Non-durable goods	13
Durable goods	67

Note: OECD stands for Organisation for Economic Co-operation and Development.

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

While GVCs were more prevalent in high technology, R&D, and capital goods industries, the benefits of GVC participation extended across many industries (Table 7). GVC starters in high-technology industries (where GVCs are most evident) had nearly double the gain in productivity growth over all time periods, compared with an average GVC starter. However, the gains were not statistically significant, likely because of the small number of observations in the sector: about 12% of those in other industrial groups. GVC starters in medium-low-technology and low-technology industries (or according to the second classification system, the natural-resource-based, labour-intensive and scale-based sectors) had statistically significant gains in accumulated productivity growth over all periods. GVC starters in the durable goods sector experienced slightly lower productivity gains than did their counterparts in the non-durable goods sector (6% versus 14% in accumulated productivity growth four years after becoming a GVC).

Table 7

Association between change in global-value-chain status and accumulated productivity growth, by industry groups, manufacturing firms, Canada, 2002 to 2006

	Accumulated productivity growth by number of years after GVC status change							
	GVC starters versus non-GVC firms				GVC stoppers versus GVC continuers			
	1 year	2 years	3 years	4 years	1 year	2 years	3 years	4 years
	coefficient							
All manufacturing industries	0.05 **	0.05 **	0.06 **	0.09 **	-0.01	-0.04 **	-0.04 *	-0.07 *
Technology level								
High-technology	0.08	0.09	0.15	0.29	0.05	0.04	0.00	-0.04
Medium-high-technology	0.05 **	0.03	0.04	-0.02	-0.03 †	-0.11 **	-0.04	-0.14 *
Medium-low-technology	0.05 **	0.07 **	0.05	0.11 †	0.00	-0.04 †	-0.11 **	-0.06
Low-technology	0.05 **	0.05 *	0.07 **	0.09 *	0.00	-0.01	0.02	-0.03
OECD industrial sectors								
Natural-resource-based	0.06 **	0.04	0.09 †	0.18 †	0.01	0.00	0.00	0.01
Labour-intensive	0.03 *	0.09 **	0.07 *	0.11 **	-0.03 *	-0.03	-0.07 *	-0.12 *
Scale-based	0.06 **	0.05	0.11 *	0.18 *	0.04 *	-0.10 **	-0.14 **	-0.09
Product-differentiated	0.08 **	0.03	-0.01	-0.03	-0.01	-0.08 **	-0.04	-0.15 *
Science-based	0.03	0.06	0.09	0.02	-0.02	-0.18 *	-0.01	0.00
Durable versus non-durable goods								
Non-durable goods	0.06 **	0.08 **	0.09 **	0.14 *	0.01	-0.01	0.01	-0.01
Durable goods	0.05 **	0.04 *	0.03	0.06 *	-0.01	-0.07 **	-0.08 **	-0.11 **

** significantly different from reference category ($p<0.01$)

* significantly different from reference category ($p<0.05$)

† significantly different from reference category ($p<0.10$)

Notes: OECD stands for Organisation for Economic Co-operation and Development; GVC stands for global value chain.

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

When GVC stoppers are compared with continuing GVC firms, the largest negative impact of abandoning GVC status was for medium-high- and medium-low-technology industries (alternatively, labour-intensive, scale-based, and product-differentiated sectors).

4.3 Global value chain participation process

GVC starters fall into three categories: non-trading firms that start offshoring (importing intermediates) and exporting simultaneously; exporters that start importing; and importers that start exporting. Similarly, GVC stoppers can be classified as: firms that cease offshoring and exporting simultaneously; exporters that cease importing; and importers that cease exporting.

For most firms, entry into or exit from GVC status is a gradual process (Table 8). For example, 91% of starters were already exporters or importers before becoming both, and 90% of stoppers ceased exporting or importing, but not both. Among the gradual GVC starters, the majority (72%) were importers who began exporting. The majority (70%) of GVC stoppers were importers who stopped exporting. The advantages of vertical relationships are more often than not established first at the import level, and then, broadened to the export level.

Table 8
Number and percentage distribution of global-value-chain (GVC) starters and stoppers, by GVC participation process, manufacturing firms, Canada, 2002/2003 to 2005/2006

	2002/2003	2003/2004	2004/2005	2005/2006	Averages (2002 to 2006)
			number		
All GVC starters	3,599	2,861	2,246	1,758	2,616
			percent		
Starting both imports and exports	13	10	8	8	10
Exporters starting imports	18	15	18	23	19
Importers starting exports	69	76	74	68	72
			number		
All GVC stoppers	3,773	2,424	2,361	1,939	2,624
			percent		
Stopping both imports and exports	13	11	8	10	10
Stopping imports only	20	17	23	19	20
Stopping exports only	67	72	68	71	70

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

To examine how productivity gains (losses) differ with the process that leads to a particular GVC status, propensity matching is conducted separately for each group of starters and stoppers by NAICS 3-digit industry. Adjusting simultaneously on both the export and import side rarely had a significant impact. But firms that were already importers who adjusted by changing their export status experienced a significant long-run change in their productivity growth. Importers experienced an immediate gain of 5% in productivity that cumulates to 10% four years after the decision to start exporting. Baldwin and Gu (2004) demonstrated that productivity gains associated with exporting are connected with technological innovation (Table 9). This gain cumulates over time as might be expected if it is associated with a gradual learning process.

Table 9

Association between change in global-value-chain (GVC) status and accumulated productivity growth, by GVC participation process, manufacturing firms, Canada, 2002 to 2006

	Accumulated productivity growth by number of years after GVC status change							
	GVC starters versus non-GVC firms				GVC stoppers versus GVC continuers			
	1 year	2 years	3 years	4 years	1 year	2 years	3 years	4 years
	coefficient							
Starting/stopping both imports and exports	0.04	0.07	-0.02	0.01	-0.04	-0.04	-0.10 *	-0.09
Exporters starting/stopping imports	0.03 †	0.00	0.07	0.04	-0.07 **	-0.13 **	-0.09 *	-0.09
Importers starting/stopping exports	0.05 **	0.08 **	0.12 **	0.10 *	0.00	-0.01	-0.01	-0.08 *

** significantly different from reference category (p<0.01)

* significantly different from reference category (p<0.05)

† significantly different from reference category (p<0.10)

Sources: Statistics Canada, Annual Survey of Manufactures and Importer Register.

Exporters that adjusted through changing their import status experienced an immediate impact on their productivity growth. Exporters that stopped importing had a 7% loss in productivity growth in the first year after the transition, whose immediacy suggests that the gains come from a cost efficiency that is readily incorporated in the production process—either because it comes from adopting a technology needed for the import's use, or because it involves a one-time gain in quality or cost. The loss increased in a non-monotonic fashion over time.

4.4 Import sources and export destinations

To examine how the gains from joining a GVC differ across trading partners, countries are classified as low-wage or high-wage countries, with $12,000 average gross domestic product (GDP) per capita as the dividing point.[10] The low-wage category includes some of Canada's major trading partners: Mexico and China.

The percentages of intermediate imports from and exports to low-wage versus high-wage countries were similar for GVC and non-GVC firms. Both GVC and non-GVC firms imported 12% to 15% of intermediates from low-wage countries, and exported 4% to 5% of products to such countries (Table 10). Both GVC firms and non-GVC firms have increasingly shifted their trade from high-wage to low-wage countries. Between 2002 and 2006, the percentage of imported intermediates from low-wage countries grew at an annual average rate of 12% for GVC firms and 17% for non-GVC firms; the percentage of exports destined for low-wage countries rose at an average annual rate of 13% for GVC firms, and 12% for non-GVC firms.

Table 10
Percentage distribution of import sources and export destinations, by global-value-chain (GVC) status, manufacturing firms, Canada, 2002 to 2006

	2002	2003	2004	2005	2006	Annual average	Annual average percent change
			percent				percent change
Intermediate import source							
GVC firms							
Low-wage countries	11	12	14	17	18	15	12
High-wage countries	89	88	86	83	82	85	-2
Non-GVC firms							
Low-wage countries	8	7	12	19	16	12	17
High-wage countries	92	93	88	81	84	88	-2
Export destination							
GVC firms							
Low-wage countries	3	4	4	5	5	4	13
High-wage countries	97	96	96	95	95	96	-1
Non-GVC firms							
Low-wage countries	4	4	5	5	7	5	12
High-wage countries	96	96	95	95	93	95	-1

Sources: Statistics Canada, Annual Survey of Manufactures, Importer Register and Exporter Register.

10. GDP per capita is based on purchasing power parity, averaged over the 2002-to-2006 period. The data are from the World Bank.

To investigate whether the productivity gain from GVC participation is mainly driven by firms trading with high-wage countries, two groups of GVC starters (importers beginning to export, and exporters beginning to import) and two groups of GVC stoppers (importers ceasing to export, and exporters ceasing to import) are subdivided by country of source or destination. For example, importers are split into those that begin exporting only to low-wage countries versus only to high-wage countries; firms that begin exporting to both low-wage and high-wage countries are excluded. Each subgroup is matched separately to their corresponding control groups using propensity matching by NAICS 3-digit industry. To avoid conflating the effects of multiple GVC entry and exit to different country groups, and to avoid the imprecision in estimates arising from a small number of observations, the immediate effect of GVC status is estimated by country only for the first year by pooling matched data across industries.

The estimates of the immediate increase in productivity are presented in Table 11. Comparisons with Table 9 can be used to determine the difference in the productivity performance of GVC starters and non-GVC firms. Exporters who began importing intermediates had a 3% immediate gain in productivity growth, compared with non-GVC firms (Table 9). The gain was driven by imports from high-wage countries (Table 11). On the other hand, exporters who ceased importing suffered a 7% immediate drop in productivity growth (Table 9). These losses occurred for both sources of imports. Firms that ceased importing only from low-wage countries suffered sharper productivity losses than did firms that ceased importing only from high-wage countries (14% versus 4%). The losses were concentrated in low-technology sectors (Table 11).[11] This difference accords with an explanation that some of the gains stem from cost savings.

11. The four industries that differed according to technological intensity in the first industry classification taxonomy were grouped into two sectors: low (comprising low- and medium-low-technology industries) and high (comprising medium-high- and high-technology industries). The low-technology sector roughly corresponds to the natural-resource-based and labour-intensive sectors in the next taxonomy classification.

Table 11
Association between change in global value chain (GVC) status and immediate productivity growth, by GVC participation process and source/destination countries, manufacturing firms, Canada, 2002 to 2006

	All industries	Low-technology industries	High-technology industries
		coefficient	
GVC starters compared to non-GVC firms			
GVC starters—exporters start imports from			
Low wage countries	-0.03	-0.07	0.16
High wage countries	0.04 *	0.03	0.07
GVC starters—importers start exports to			
Low wage countries	0.05	0.06	0.04
High wage countries	0.07 **	0.07 **	0.07 **
GVC stoppers compared to continuing GVC firms			
GVC stoppers—exporters stop imports from			
Low wage countries	-0.14 *	-0.17 *	-0.07
High wage countries	-0.04 *	-0.05 *	-0.03
GVC stoppers—importers stop exports to			
Low wage countries	0.07	0.03	0.32
High wage countries	0.01	0.02 †	-0.02

** significantly different from reference category ($p<0.01$)

* significantly different from reference category ($p<0.05$)

† significantly different from reference category ($p<0.10$)

Sources: Statistics Canada, Annual Survey of Manufactures, Importer Register and Exporter Register.

Offshoring may enhance productivity in a number of ways. Importing intermediates from low-wage countries may result in cost savings. Offshoring may increase efficiency if the imported goods are of higher quality, or if it facilitates technology diffusion and learning spillovers (Kelly 2004), which is more likely if the imports are from a high-wage country. Firms may also realize efficiencies by offshoring less productive stages of manufacturing and shifting resources toward more productive activities. The finding of changing productivity growth associated with both starting and stopping imports from high-wage countries suggests that technology diffusion may be a factor in the benefits of offshoring. But the fact that stopping imports from low-wage countries reduces productivity the most suggests that cost savings of offshoring to low-wage countries are also important.

The previous section reported that importers who began exporting experienced an immediate 5% gain in productivity growth (Table 9). These gains were driven by exports only to high-wage countries (7%). Exporting only to low-wage countries also generated immediate gains (5%), but these gains were not significant. Loecker (2007), too, found higher productivity premiums for firms exporting to more developed regions. This is consistent with the learning-by-exporting hypothesis—exporters acquire technological knowledge from buyers in high-wage countries.[12] Importers who ceased exporting did not suffer from an immediate decline in productivity growth, but rather did so gradually over time (Table 9). The lack of immediate effect was independent of the income level of the destination of exports (Table 11).

5 Conclusion

Fragmentation of production in GVCs leads to a finer division of labour and specialization across nations. Increasingly, Canadian manufacturers are being vertically integrated into GVCs—importing intermediates to produce goods that are later exported. This paper analyzes the effects of participation in GVCs on the productivity performance of Canadian manufacturing firms.

More productive firms may self-select to join GVCs. The 28% of Canadian manufacturing firms that participated in GVCs during the 2002-to-2006 period tended to be more productive and larger, and to pay higher wages.

To control for bias introduced by this self-selection, propensity-score matching and difference-in-difference methods were used to analyze the impact that participating in a GVC had on productivity.

GVC starters became more productive, and this better performance continued into future years. GVC stoppers suffered a loss in productivity in both the short- and long-run.

The magnitude and timing of the effects of GVC status vary by industrial sector, the route adopted for becoming a GVC, and import-source/export-destination country. Around 50% of firms in high- and medium-high-technology industries (roughly corresponding to product-differentiated and science-based sectors) were integrated into GVCs, compared with the overall average of 28%. The productivity benefits of GVC participation were particularly evident in the high-technology sector—almost double the gain of an average GVC starter. The effects for labour-intensive and scale-based industries were also positive and statistically significant. Thus, while GVCs were more prevalent in high technology, R&D, and capital goods industries, the benefits of GVC participation extended across many industries—probably because technology transfer matters everywhere.

For around 90% of Canadian manufacturing firms that entered or exited a GVC, the process was incremental. The advantages of vertical relationship were established first by importing, and then, broadened to the export level. Some 70% of firms responded to changes in incentives to adopt or abandon GVC status mainly through export markets. Those who adjusted through exporting benefited the most in terms of productivity growth in the long run. Firms that adjusted through importing saw a more immediate gain or loss in productivity. This suggests that the cost-saving effect of offshoring is more immediate than the learning effects of exporting.

While Canada's trade with low-wage countries has been increasing, high-wage countries remain the major source of imported intermediates and destination for exports. Productivity growth was higher for GVC firms that imported intermediates from and exported products to these high-wage countries. This is consistent with the learning-by-exporting hypothesis and the hypothesis

12. For other evidence, see Baldwin and Gu (2004).

that imports provide a channel of technology diffusion: firms learn more by dealing with buyers and sellers from countries with technological and managerial sophistication. Along with the finding that productivity gains for new GVCs were greatest in the technology sector, this bolsters the inference that a major source of benefit from becoming a GVC comes from technology transfer.

Low-technology firms that ceased being GVCs by terminating imports from low-wage countries suffered the greatest loss in productivity. This suggests a separate benefit of GVC status can be found in cost-savings but that this is primarily restricted to trade with those countries where potential cost-savings are highest.

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